

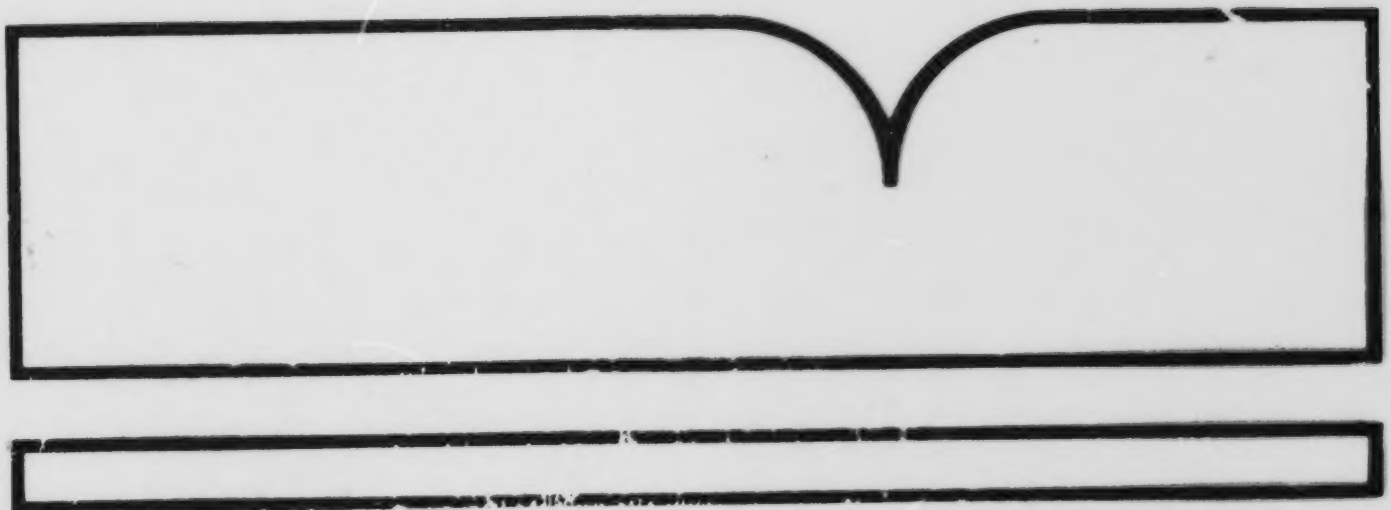
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Pesticide Orchard Ecosystem Model (POEM)
A User's Guide

Michigan State Univ., East Lansing

Prepared for
Corvallis Environmental Research Lab., OR

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A User's Guide

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ABSTRACT

A mathematical model was developed to predict the transport and effects of a pesticide in an orchard ecosystem. The environmental behavior of azinphosmethyl was studied over a 2-year period in a Michigan apple orchard to gather data for the model on initial distribution within the orchard, influence of rainfall on vertical movement, loss via runoff, and effects on selected orchard invertebrate populations. Following model development, a third year of field data was collected for comparison with model projections. Mean squared errors for the comparison of predicted vs. observed residue data indicate good predictions of azinphosmethyl fate within the tree and grass/broadleaves layers. Prediction of pesticide dynamics within the litter/moss and soil layers was much more variable.

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Introduction

The Pesticide Orchard Ecosystem Model was constructed for two major reasons:

- (1) to assist in presenting the results of a study of the fate of a particular compound under field conditions and its effects on some significant organisms using laboratory and field data; and
- (2) to allow users to explore the implications of changes in the model's parameters on the model outcomes (both fate and effects), including limited extrapolation to other compounds and/or field conditions.

The various submodels included in POEM and the methods used to parameterize them are described in the main text of this report and in a series of publications (see Bibliography). This guide is intended as a supplement, to aid persons desiring to run the associated computer programs. No explanation is offered here of the methods used to derive the parameters included as default values, nor is there any presentation of results (see main report and companion computer tape, Goodman et al., 1981a, b).

POEM is a modular FORTRAN IV program, composed of many subunits which may be invoked or left idle during any particular run. In general, POEM units not needed should be "turned off" to minimize computer costs. POEM may be used to explore the behavior of the fate model using "average" values independent of temperature and relative humidity, or may be instructed to recalculate certain parameters daily, based on environmental conditions. Many of POEM's parameters for azinphosmethyl may be altered to incorporate new data or determine the effects of such changes on pesticide distribution or effects on the modeled populations. Other alterations allow the user to enter information to simulate a different compound. Weather data may be entered by the user, or the program may be used to generate simulated weather data. The user must supply pesticide application information, unless the default regime used in our field studies is desired.

In its simplest use, POEM can be used with minimal input data and will produce predictions of the pesticide distributions and populations to be found in our study orchard under our measured environmental conditions from 1976-1978. POEM produces output files suitable for plotting, and two plotting programs are included (one for pesticide residues, one for populations). Alteration of compound characteristics, weather data, or process-specific parameters may require the user to enter much larger amounts of data, although it is relatively easy and often enlightening to explore the effects of changing one or a few parameters at a time.

The next few sections describe the general nature of the units in the fate model, followed by directions for and examples of reparameterization. A brief description of the organism submodels is included under Organism Graphs; however, the automatic alteration of organism model parameters has not yet been completely implemented. See the relevant sections of the main text for more information.

Attenuation of Pesticide

The attenuation model simulates attenuation, other than penetration, in the various compartments. Each compartment has an attenuation proportion -- the proportion of pesticide within or entering that compartment during one day that is attenuated (see below) from that compartment during a one-day time step at standard conditions. The standard conditions approximate the average of those prevailing during collection of the field data used to parameterize this model. These conditions are:

(1) environmental conditions

- soil pH = 7.0
- % organic matter of soil = 6%

(2) compound properties

- molecular weight = 317
- vapor pressure = 10^{-7} atm.

Each compartment's attenuation proportion is further broken down into five attenuation processes: hydrolysis, photolysis, oxidation, volatilization, and microbial degradation. Therefore, each compartment has an attenuation proportion for each of the five attenuation processes. The sum of the attenuation proportions for each process of a given compartment is equal to the overall attenuation proportion for that compartment.

The user has the option of using the overall attenuation proportions for each compartment directly as the proportion of pesticide lost each day due to attenuation. Or the user may allow individual attenuation proportions of the attenuation process to vary with environmental conditions. Thus, the sum of the attenuation proportions of the five attenuation processes over a compartment, which yields the day's overall attenuation proportion for that compartment, will vary daily with environmental conditions. In addition, the user may alter certain default parameters to represent properties of a compound other than azinphosmethyl, the compound used in the field studies. The overall attenuation proportions, whether constant or varied with daily conditions, are applied each day and represent the proportions of pesticide attenuated daily from each compartment.

Non-Rainfall Movement of Pesticide

Subroutine Nonrain simulates the daily movement of pesticide within the orchard independent of the rainfall during the period (i.e., it is applied every day). It operates conservatively; that is, it moves residues without any losses, which must therefore be accounted for elsewhere in the model (see Attenuation description in previous section). It operates only on dislodgeable residues, except that residues entering the soil layers are considered to be "penetrated residues." Pesticide is assumed to move only from a higher layer to lower layers, and pesticide moving to the alley region from the canopy region may only come from the canopy leaves compartment. The order of layers from highest layer to lowest layer is leaves, grass, litter-moss, and soil. The pesticide is moved via a lower triangular matrix "NRMOVE".

		CANOPY				FROM ALLEY			
		LEAVES							
CANOPY	LEAVES	A	GRASS						
	GRASS	B	H	LITTER-MOSS					
	LITTER-MOSS	C	I	K	SOIL				
	SOIL	D	J	L	M	LEAVES			
ALLEY	LEAVES						GRASS		
	GRASS	E					N	LITTER-MOSS	
	LITTER-MOSS	F					O	Q	SOIL
	SOIL	G					P	R	S

Each entry in the matrix represents a proportion of the total amount of dislodgeable pesticide residue present on a given day that moves from one compartment to another or (for diagonal entries) that remains in the same compartment. The latter (diagonal) entries in the matrix are A, H, K, M, N, Q, S. A single column in the matrix represents the movement from an individual compartment over a one-day time step. Being proportions of the total amount of what was in a compartment, all entries of any column in the matrix must sum to one. Since there is only one entry for each of the canopy soil and alley soil compartments, entry M = 1.0 and entry S = 1.0 by the definition that the columns must sum to one (implying that pesticide undergoes no non-rain-induced movement out of soil layers).

For example:

B is the proportion of pesticide moving from the canopy leaves compartment to the canopy grass compartment during a one-day time step. H is the proportion of the canopy grass compartment that remains in the canopy grass compartment during a one-day time step. Thus, the entire amount of dislodgeable pesticide in the canopy grass on day $t + 1$ (excluding attenuation) is equal to the B times the amount of dislodgeable pesticide in the canopy leaves on day t plus H times the amount of dislodgeable pesticide in the canopy grass on day t :

$$\text{CanGr}(t + 1) = B \cdot \text{CanLvs}(t) + H \cdot \text{CanGr}(t)$$

The absolute amount of pesticide for any compartment of day $t + 1$ can be represented by the sum of each entry in that compartment's "T0" row of the matrix, multiplied by the absolute amount of pesticide on day t in the appropriate compartment (neglecting attenuation and rainfall-induced movement).

It is important that pesticide values be converted from their normal form of $\mu\text{g}/\text{cm}^2$ ground area to an absolute amount (in μg) of pesticide when applying the matrix. This is because canopy and alley regions do not necessarily have the same ground areas and because the canopy leaves may move pesticide from the canopy region into the alley region. In order for the system to be conservative, the pesticide values in $\mu\text{g}/\text{cm}^2$ ground area are converted to amount of pesticide in μg before the matrix is applied and converted back to $\mu\text{g}/\text{cm}^2$ ground area afterwards.

The non-rain movement matrix is applied every day regardless of rainfall. It represents the daily movement, other than by rainfall, of the pesticide within the orchard system.

The default values of the non-rain movement matrix are those parameterized from field data.

It is possible to change the matrix during reparameterization in a variety of ways as described under the Movement Parameters category of the Reparameterization section.

Movement of Pesticide Due to Rainfall

Subroutine Rain simulates movement of pesticides within the system due to rainfall. There are two rainfall matrices that have the same properties and are applied similarly to the non-rain movement matrix. One of the two matrices is applied on each day of measurable rainfall. One represents light rainfall movement; the other represents heavy rainfall movement. A heavy rain is classified as greater than or equal to 10 mm on a given day. Less than 10 mm rain is considered a light rain. Rainfall movement is defined as additional movement beyond the non-rain movement extracted daily.

It is also possible to change either or both rainfall matrices from their default conditions. See Movement Parameters under the Reparameterization section for further details.

Application of Pesticide

Subroutine Sprayer simulates the application of pesticide to the orchard. The total amount of pesticide (in μg) that reaches the orchard is first calculated. It is equal to the amount applied (in kg/ha) multiplied times the area of the orchard (in ha) times a kilogram to microgram conversion factor (10^{-9}) times the compound formulation fraction times the proportion of pesticide that does not drift away from the orchard site. This yields the absolute amount of pesticide (in micrograms) that reached the orchard site. The proportion of drift is calculated based on the wind speed. Once the absolute amount of pesticide reaching the orchard is known, it is divided among the compartments using a spray distribution vector, "PDIST", where an entry represents the proportion of pesticide going to a specific compartment from the total amount of pesticide reaching the orchard. Thus, the sum of all entries in the spray distribution vector is equal to one.

However, some of the pesticide that reaches a compartment becomes penetrated residue. The spray distribution only gives the amount of pesticide that reaches a compartment. The pesticide that reaches each compartment, except for soil layers (all pesticide in the soil is assumed penetrated), is further divided into dislodgeable and penetrated residues. Finally, units are converted from μg to $\mu\text{g/cm}^2$ by dividing the absolute amount of pesticide in each layer by the area of its region (canopy or alley).

The spray distribution vector may be altered to a new form in the Movement Parameters section of the Reparameterization section. Likewise, initial penetrations of a layer may also be changed in the Penetration Parameters section of the Reparameterization section.

Penetrated Residue Attenuation

Subroutine Penetrat simulates the penetration of dislodgeable residues to become penetrated residues and the attenuation of penetrated residues. There is a daily penetration rate representing the proportion of dislodgeable residue that penetrates each day, and a penetrated residue attenuation proportion representing the proportion of penetrated residue that attenuates daily. Each of the proportions is applied daily regardless of spraying. Also, the proportions may be changed in the Penetration Parameters category of Reparameterization.

Mowing of the Orchard

Subroutine Mower simulates mowing of the orchard. It moves a proportion of pesticide from the grass layer to the litter-moss layer. The proportion of grass moved, "PGRASM", may be changed to any proportion (0.0 to 1.0) in the movement parameters category during reparameterization of the model. The default value of "PGRASM" for the field site is 0.0. The proportion of the grass layer moving to the litter-moss layer is assumed linear with the proportion of pesticide moving from the grass layer to the litter-moss layer because of mowing.

The maximum number of mow dates allowed for any one season is ten. The user may select any dates he wishes. The mow dates for a season are entered just before the beginning of that season.

Leaf Growth of Trees

Subroutine Trees computes the tree interception index "TII", a value which converts the ground area under the canopy region to tree surface area (including leaves). Growth in surface area is driven by degree days until petal fall (1100 degree days, base 43°F), and then is considered linear until 56 days after petal fall, at which time the TII has reached maximum.

Running the Model

The user has many options in running POEM -- some of these options call for the use of pre-stored files of weather data. For example, if the weather simulator is not used, POEM will attach a file called WTHRSTATSNEW, which should contain the weather information you wish to use (a file with 3 years of data for Grand Rapids, Missouri, is included). Similarly, if the soil moisture model is not used, POEM will seek soil moisture data from a file called PWSMOIST2. (On non-MSU systems, subroutine PARMINT should be altered to conform to local procedures for accessing these files. For more information, see section entitled "Attaching Tapes.")

Output from POEM is available in two forms -- printed tables and graphs. Graphical output is provided by specifying to POEM that graphical output is desired. Two types of graphs are available: pesticide levels versus time and population levels versus time. Pesticide level graphs are obtained by turning on option (14) (see below) and post-processing using program DATAPLT (available on the MSU CYBER as ORCHARDCALPLOT6 for CALCOMP plotter output or ORCHARETEKPL0TB for Tektronix terminal display via PLOT-10 subroutines). Population graphs are produced from files generated whenever the organism submodel (option 1) is on, using program ORGPLOT (again, available on MSU's CYBER in CALCOMP and Tektronix versions). For more information on the plotting programs, see section "Producing Graphs" below.

Printed output to display pesticide levels and/or the current rates of pesticide movement and attenuation are available in POEM as described below. Printed output from organism models is not specifically provided for, but is available by listing the plotting files generated by POEM.

Options and submodels turned on by default as execution begins are listed, followed by a list of other available options. The user then has the opportunity to turn off any options that are on by default or turn on any of the options that are off by default, in response to queries from the program. The submodels that each option represents are:

Option 1 Organism Submodels. "1" for any one or combination of the 4 organism models provided (isopod, collembolan, spider, or earthworm); further options will be presented, or "2" otherwise.

- Option 2 Mower Submodel. "1" for periodic mowing of the orchard each season. The maximum number of mows allowed each year is 10. The mow dates for a given year are entered at the start of that year.
- Option 3 Attenuation Submodel. "1" to use attenuation as a lumped process or to use any of the attenuation submodels (microbial degradation, hydrolysis, photolysis, volatilization, oxidation); "2" to bypass pesticide attenuation calculations.

(Any further reparameterization concerning these attenuation processes is done in the general category of attenuation parameters, below.)

- Option 4 Weather Submodel. "1" to turn on simulated weather. To allow true recorded weather conditions, the weather simulator must be turned off. In that case, the recorded weather must be provided on tape 4 and must contain the following conditions for each day in a required format:

- minimum and maximum air temperature (°F)
- minimum and maximum percent relative humidity
- average wind speed (mi/hr) and total rain (mm)

See Attaching Tapes for more information.

- Option 5 Nonrain Movement Submodel. "1" to select daily movement of pesticide; "2" suppresses movement except on days with rain.
- Option 6 Sprayer Submodel. "1" for periodic spraying of pesticide during the season. The maximum number of sprays each year is ten. The spray dates and spray amounts for a given year are entered at the start of that year, unless default dates and amounts are desired.
- Option 7 Rainfall Submodel. "1" for additional pesticide movement (other than daily non-rain movement) due to rainfall if rainfall is present; "2" suppresses pesticide movement in response to rainfall.
- Option 8 Penetration Submodel. "1" for pesticide penetration submodel. Any further reparameterization concerning penetration (see text) is found in the general category of penetration parameters. If option 8 is off, the proportions of daily penetration are assumed to be accounted for by other attenuation processes, provided option 3 is turned on.
- Option 9 Soil Moisture Model. "1" for simulated soil moisture based on amount of rainfall. True recorded soil moisture values may be provided, but the simulated soil moisture model must be turned off. If the soil moisture model is off, recorded soil moisture must be provided on tape 9. See Attaching Tapes for more details.
- Option 10 Tree Growth Submodel. "1" for daily leaf and tree growth based on degree days.

- Option 11 Movement Matrix Printout. Provides daily printout of a matrix which combines the non-rain movement matrix with the attenuation matrix. This matrix captures the net effects of the environment-dependent processes acting on the pesticide, under non-rainfall conditions, as presented by the model. Beginning and ending dates for printout of this matrix for a given year are entered at the start of that year. This option is provided to see movement and attenuation that vary daily with environmental conditions, as influenced by compound properties.
- Option 12 Soil Transportation Model. "1" selects more detailed model of soil layer.
- Option 13 Pesticide Output. "1" selects printing periodic pesticide values; mow, rain, and spray date flags are also printed.
- Option 14 Plotting Output. "1" writes formatted file of pesticide values to tape 1, file of spray dates to tape 2, and file of rain dates and amounts to tape 3 for plotting package. See Plotting Package for more details.
- Option 15 Event Dates. "1" allows the user to enter dates of events of sprays and mows. If this option is off, event dates are those from field data used to parameterize this program.
- Option 16 Variable Attenuation. "1" allows daily attenuation proportions of the various attenuation processes to vary daily with environmental conditions, and to reflect compound properties other than those of azinphosmethyl. If option 16 is off, attenuation proportions will be identical each day, and based on the measured values for azinphosmethyl.

If the user selects the organism model option, he must then select one or any combination of the four organism models (isopod, collembolan, spider, earthworm). He is asked individually for each organism model to be turned on or off.

If organism models are desired without the effects of pesticide, then the sprayer (option 6) should be off. Therefore, no pesticide is sprayed to the orchard.

It is suggested that if the sprayer option is off, then options 2, 3, 5, 7, 8, 10, 11, 12, 13, and 14 also be off since all of these submodel options pertain to movement or output of pesticide and no pesticide can be present without the sprayer submodel. Additionally, option 16 deals with attenuation and has no effect unless option 3 is on.

Sample

THE FOLLOWING OPTIONS ARE ON BY DEFAULT

ORGANISM SUBMODEL
ATTENUATION SUBMODEL
NON-RAIN MOVEMENT SUBMODEL
PESTICIDE APPLICATION SUBMODEL
RAINFALL MOVEMENT SUBMODEL
PENETRATION SUBMODEL
WRITE FILES FOR PLOTTING PACKAGE
VARIABLE ATTENUATION

OTHER AVAILABLE OPTIONS ARE

MOWER SUBMODEL
WEATHER SIMULATOR
SOIL MOISTURE SIMULATOR
LEAF GROWTH SUBMODEL
MOVEMENT MATRIX DAILY OUTPUT
SOIL TRANSPORTATION SUBMODEL
PESTICIDE PRINTOUT
NON-DEFAULT EVENT DATES -- SPRAYS, MOWS, ETC

DO YOU WISH TO TURN ON OR OFF ANY OPTIONS?

(1) YES (2) NO 1

ENTER A VALUE FOR EACH OPTION

(1) FOR OPTION ON	(2) FOR OPTION OFF
OPTION 1	ORGANISM SUBMODEL 2
OPTION 2	MOWER SUBMODEL 1
OPTION 3	ATTENUATION SUBMODEL 1
OPTION 4	WEATHER SIMULATOR 2
OPTION 5	NON-RAIN MOVEMENT SUBMODEL 1
OPTION 6	PESTICIDE APPLICATION SUBMODEL 1
OPTION 7	RAINFALL MOVEMENT SUBMODEL 1
OPTION 8	PENETRATION SUBMODEL 1
OPTION 9	SOIL MOISTURE SIMULATOR 2
OPTION 10	LEAF GROWTH SUBMODEL 2
OPTION 11	MOVEMENT MATRIX DAILY OUTPUT 1
OPTION 12	SOIL TRANSPORTATION SUBMODEL 2
OPTION 13	PESTICIDE PRINTOUT 1
OPTION 14	WRITE FILES FOR PLOTTING PACKAGE 2
OPTION 15	NON-DEFAULT EVENT DATES -- SPRAYS, MOWS, ETC 1
OPTION 16	VARIABLE ATTENUATION 1

After the correct submodel choices have been selected, other simulation parameters are entered.

First, the user is asked how many years to run the model. The maximum number of years is ten, and the model must be run at least one year.

Second, if the user has chosen option 13 of the on-off vector, he is asked how often in days he would like pesticide value printed to output. Selecting pesticide output (option 13) automatically causes printing of mow,

spray, and rain dates where they are appropriate, along with pesticide values on spray dates. If the user inputs "10" for the pesticide value printout increment, pesticide values will also be printed to output every ten days.

Example

HOW MANY YEARS DO YOU WISH TO SIMULATE (ONE TO TEN YEARS) 1

HOW OFTEN (IN DAYS) WOULD YOU LIKE PESTICIDE VALUES PRINTED TO OUTPUT 1

Reparameterization

General Categories of Reparameterization

Reparameterization is divided into five general categories. If the user chooses to reparameterize, he must select one of these general categories. The five categories are:

(1) physical site characteristics

- basic site characteristics (areas, # trees, % alley, and canopy area)
- site characteristics needed for soil moisture model (altitude, latitude, soil moisture, field capacity, etc.)

(2) attenuation parameters

- attenuation proportions
- environmental properties (soil pH, % organic matter)
- coefficients of equations dependent on environmental conditions
- compound properties

(3) penetration parameters

- initial penetration rates
- daily penetration rates
- penetrated residue attenuation rates

(4) pesticide movement parameters

- spray distribution
- non-rain movement matrix
- rainfall movement matrix
- proportion of grass mowed

(5) organism parameters

- isopod parameters
- collembolan parameters
- spider parameters
- earthworm parameters

When entering options to select from, the user inputs the number of the option he wishes. When the user is asked for more than one input value for a given line, each of the values must be separated by blank(s) or a comma.

Example

DO YOU WANT TO REPARAMETERIZE THE MODEL (DEFAULT VALUES ARE BASED ON ESTIMATES FOR AZINPHOSMETHYL AS GUTHION 50 W.P.)

(1) YES (2) NO 1

DO YOU WISH TO CHANGE (1) PHYSICAL CHARACTERISTICS OF SITE (2) ATTENUATION PARAMETERS (3) PENETRATION PARAMETERS (4) MOVEMENT PARAMETERS (5) ORGANISM PARAMETERS 2

After a general category is selected and reparameterization is completed for that category, the user will be asked if he wishes to continue reparameterization. If he selects "NO", execution will begin. However, if he selects "YES", he may select any general category originally offered including the one just completed.

All dates asked for should be entered in a Julian date format (a number from 1 to 365 representing which day of the year it is; i.e., February 1 would be day 32 because it is the 32nd day of the year). Leap years are ignored, so day 365 is the maximum date for any year.

1. Physical Characteristics of Orchard Site

This category first asks for basic physical characteristics defining the site. Values for total area of site, amount of site that is canopy region (remainder is alley region), and the number of trees in the site requested one at a time. When asking for one of these values, the model will list the default condition. Default conditions are those of the field study site for which the model was originally parameterized.

If the soil moisture submodel (option 9) is on, additional physical characteristics (initial percent soil moisture, field capacity for soil moisture, altitude of site, latitude of site, etc.) necessary for the soil moisture submodel are asked for in the same manner as the other physical site characteristics.

Example

DO YOU WISH TO CHANGE (1) PHYSICAL CHARACTERISTICS OF SITE (2) ATTENUATION
PARAMETERS (3) PENETRATION PARAMETERS (4) MOVEMENT PARAMETERS
(5) ORGANISM PARAMETERS 1

HOW MANY HECTARES OF GROUND AREA WOULD YOU LIKE YOUR ORCHARD?
(CURRENT AREA = 0.0812 HA) 1.0

HOW MUCH (IN HECTARES) OF THE 1.0000 HECTARE ORCHARD WILL BE CANOPY REGION
(CURRENT CANOPY AREA = 0.0302 HA)
(THE REMAINDER OF AREA IS CONSIDERED ALLEY REGION) 0.40

HOW MANY TREES ARE IN THIS ORCHARD?
(CURRENT NUMBER OF TREES = 60) 800

ENTER PERCENT W/W SOIL MOISTURE CONTENT AT THE FIRST DAY
(CURRENT INITIAL SOIL MOISTURE = 30.00 PERCENT W/W) 25

ENTER PERCENT W/W SOIL MOISTURE FIELD CAPACITY
(CURRENT FIELD CAPACITY = 60.00 PERCENT W/W) 60

ENTER BULK DENSITY (IN GM/CM**3) OF SOIL
(CURRENT BULK DENSITY = 1.500 GM./CM**3) 1.4

ENTER ALTITUDE (IN METERS) OF SITE
(CURRENT ALTITUDE = 200.000 M) 240

ENTER LATITUDE OF SITE
(CURRENT LATITUDE = 40.00 DEGREES) 40

ENTER DIFFERENCE IN MEAN AIR TEMPERATURES (DEGREES C) BETWEEN WARMEST AND
COOLEST MONTHS OF THE YEAR
(CURRENT DIFFERENCE = 27.80 C) 28

ENTER EVAPOTRANSPIRATION FACTOR DUE TO FLORA
(CURRENT EVAPOTRANSPIRATION FACTOR = 1.00) 1.00

ANY MORE REPARAMETERIZATION? (1) YES (2) NO 2

2. Attenuation Parameters

The attenuation parameters are divided into four basic groups: (1) lumped attenuation parameters, used only if option (16) is off, yielding constant daily rates of attenuation; (2) daily attenuation proportions for various processes (microbial degradation, volatilization, oxidation, hydrolysis, and photolysis) for the various regions and layers; (3) attenuation parameters describing effects of environmental conditions; and (4) attenuation parameters describing compound properties different from those of azinphos-methyl.

When the attenuation parameters category of reparameterization is selected, the current daily attenuation proportions at standard conditions are displayed. The standard conditions are approximately the average of the conditions obtained during the collection of the field data used to parameterize the model. These conditions are:

(1) environmental conditions

- soil pH = 7.0
- % organic matter of soil = 6%

(2) compound properties

- molecular weight = 317
- vapor pressure = 10^{-7} atm.

The daily attenuation proportion matrix represents proportions of the amount of pesticide in each region and layer that is attenuated under the above standard conditions during one day.

If option (16) is off, and after the attenuation proportion matrix is displayed, the user may change any number of entries in the matrix one at a time, display the new matrix after some entries have been changed, or exit the daily attenuation proportion matrix change mode once he is satisfied with attenuation proportions at standard conditions.

Example

CURRENT ATTENUATION PROPORTIONS AT STANDARD CONDITIONS ARE:

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.0487	0.0412	0.0412	0.0790
ALLEY	0.0000	0.0670	0.0670	0.0790

WOULD YOU LIKE TO (1) CHANGE AN ENTRY IN THE STANDARD CONDITION ATTENUATION MATRIX (2) SEE CURRENT DAILY ATTENUATION PROPORTIONS (3) EXIT ATTENUATION PROPORTION CHANGE MODE 1

ENTER REGION (1) CANOPY (2) ALLEY

LAYER (1) LEAVES (2) GRASS (3) LITTER-MOSS (4) SOIL
ATTENUATION PROPORTION (VALUE FROM 0.0 TO 1.0) 1 2 0.050

WOULD YOU LIKE TO (1) CHANGE AN ENTRY IN THE STANDARD CONDITION ATTENUATION MATRIX (2) SEE CURRENT DAILY ATTENUATION PROPORTIONS (3) EXIT ATTENUATION PROPORTION CHANGE MODE 2

CURRENT ATTENUATION PROPORTIONS AT STANDARD CONDITIONS ARE:

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.0487	0.0500	0.0412	0.0790
ALLEY	0.0000	0.0670	0.0670	0.0790

WOULD YOU LIKE TO (1) CHANGE AN ENTRY IN THE STANDARD CONDITION ATTENUATION MATRIX (2) SEE CURRENT DAILY ATTENUATION PROPORTIONS (3) EXIT ATTENUATION PROPORTION CHANGE MODE 3

ANY MORE REPARAMETERIZATION? (1) YES (2) NO 2

If option (16) is on, then the above matrix serves only to show standard condition totals for daily attenuation. The matrix used will be calculated daily, based on the environmental conditions. The daily attenuation proportion matrix is further subdivided, into 5 components. Each entry in the new matrix represents one of five attenuation processes (hydrolysis, photolysis, oxidation, microbial degradation, volatilization). This new daily attenuation proportion matrix, broken down by region, layer, and attenuation processes, is displayed. Its entries represent daily proportions attenuated under standard conditions, and the daily rates actually used will be these entries multiplied by environmentally-dependent factors, described below.

The user then has the option to change this new matrix. If he decides to change the matrix, he has the option to change a single entry in the matrix, the contribution of an entire process (a row in the matrix), or each process for a given region and layer (a column in the matrix). After the user makes any type of change in either of the two previous matrices (overall daily attenuation proportion matrix for a given region and layer, and the same matrix also divided by contributions of different attenuation processes), the user again has the option to change the matrix in the manner just described or keep it as it is.

Example

CURRENT ATTENUATION PROPORTIONS AT STANDARD CONDITIONS ARE:

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.0487	0.0412	0.0412	0.0790
ALLEY	0.0000	0.0670	0.0670	0.0790

THE CONTRIBUTION OF INDIVIDUAL PROCESSES TO OVERALL ATTENUATION AT STANDARD CONDITIONS ARE:

	MATRIX AP							
	C 1	C 2	C 3	C 4	A 1	A 2	A 3	A 4
MICROBIAL DEG.	0.000	0.000	0.010	0.070	0.000	0.000	0.017	0.070
HYDROLYSIS	0.012	0.012	0.015	0.009	0.000	0.019	0.025	0.009
PHOTOLYSIS	0.018	0.006	0.003	0.000	0.000	0.010	0.004	0.000
VOLATILIZATION	0.019	0.024	0.013	0.000	0.000	0.038	0.021	0.000
OXIDATION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

WOULD YOU LIKE TO CHANGE THE ATTENUATION PROPORTIONS AT STANDARD CONDITIONS ALLOCATED TO DIFFERENT TYPES OF ATTENUATION (1) YES (2) NO 1

WOULD YOU LIKE TO CHANGE (1) A SINGLE ENTRY IN THE MATRIX AP (2) A ROW IN THE MATRIX (3) A COLUMN IN THE MATRIX 1

ENTER 4 NUMBERS

FIRST NUMBER -- REGION (1) CANOPY (2) ALLEY

SECOND NUMBER -- LAYER (1) LEAVES (2) GRASS (3) LITTER-MOSS (4) SOIL

THIRD NUMBER -- PROCESS (1) MICROBIAL DEG. (2) HYDROLYSIS (3) PHOTOLYSIS
(4) VOLATILIZATION (5) OXIDATION

FOURTH NUMBER -- ATTENUATION PROPORTION FOR THE REGION, LAYER, PROCESS YOU
HAVE SELECTED (PROPORTION MUST BE FROM 0.0 TO 1.0) 1 4 1 0.060

CURRENT OVERALL ATTENUATION PROPORTIONS AT STANDARD CONDITIONS ARE:

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.0487	0.0412	0.0412	0.0690
ALLEY	0.0000	0.0670	0.0670	0.0790

THE CONTRIBUTION OF INDIVIDUAL PROCESSES TO OVERALL ATTENUATION AT STANDARD
CONDITIONS ARE:

	MATRIX AP							
	C 1	C 2	C 3	C 4	A 1	A 2	A 3	A 4
MICROBIAL DEG.	0.000	0.000	0.010	0.060	0.000	0.000	0.017	0.070
HYDROLYSIS	0.012	0.012	0.015	0.009	0.000	0.019	0.025	0.009
PHOTOLYSIS	0.018	0.006	0.003	0.000	0.000	0.010	0.004	0.000
VOLATILIZATION	0.019	0.024	0.013	0.000	0.000	0.038	0.021	0.000
OXIDATION	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

WOULD YOU LIKE TO CHANGE THE ATTENUATION PROPORTIONS AT STANDARD CONDITIONS
ALLOCATED TO DIFFERENT TYPES OF ATTENUATION (1) YES (2) NO 2

Once the daily standard attenuation proportions are set, the user has the
option to change environmental properties of the site or compound properties.
He is given standard conditions of necessary environmental and compound
properties such as soil pH, % soil organic matter, vapor pressure, etc. and
asked to input the value of the property.

Example

DO YOU WISH TO CHANGE ENVIRONMENTAL PROPERTIES OR COMPOUND PROPERTIES
(1) YES (2) NO 1

ENTER SOIL PH VALUE (CURRENT PH = 7.000) 6.5

ENTER PERCENT ORGANIC MATTER OF SOIL
(CURRENT PERCENT ORGANIC MATTER = 6.000) 6.0

MULTIPLICATIVE FACTOR FOR VOLATILIZATION IS OF THE FORM

$$F = (VP * MW^{0.5}) / (STDVP * STDMW^{0.5})$$

WHERE VP = VAPOR PRESSURE OF CURRENT COMPOUND
MW = MOLECULAR WEIGHT OF CURRENT COMPOUND
STDVP = VAPOR PRESSURE OF STANDARD COMPOUND (AZINPHOSMETHYL)
= 0.0000001 ATM.

STDMW = MOLECULAR WEIGHT OF STANDARD COMPOUND (AZINPHOSMETHYL)
= 317

ENTER COMPOUND VAPOR PRESSURE (IN ATM.)
(STANDARD COMPOUND VAPOR PRESSURE = 0.0000001000 ATM.) 0.0000001

ENTER COMPOUND MOLECULAR WEIGHT (STANDARD COMPOUND MOLECULAR WEIGHT = 317) 317

ENTER COMPOUND FORMULATION (IN PERCENT)
(STANDARD COMPOUND FORMULATION = 50.00 PERCENT WETTABLE POWDER) 50

MULTIPLICATIVE FACTOR FOR VOLATILIZATION IS OF THE FORM

$$F = (2.303/CONST) * PHI * SIGMA * AQS * DIURN / DEF$$

WHERE CONST = CONVERSION CONSTANT = $6.02 * 10^{20}$

PHI = QUANTUM YIELD

SIGMA = TOTAL PHOTONS ADSORBED (DIFFERENT FOR EACH COMPARTMENT)

AQS = A MULTIPLICATIVE FACTOR TO ALLOW FOR NATURALLY OCCURRING
LIGHT ABSORBERS, SENSITIZERS, AND QUENCHERS

DIURN = DIURNAL CONVERSION FACTOR TO LOSS RATE AT PEAK SUNLIGHT
INTENSITY TO DAILY PROPORTIONAL LOSS = $2.52 * 10^4$

DEF = ATTENUATION PROPORTION ENTRY FOR PHOTOLYSIS (DIFFERENT FOR
EACH COMPARTMENT)

ENTER QUANTUM YIELD (IN MOLES CONVERTED PER PHOTON ABSORBER)
(CURRENT QUANTUM YIELD = $1.00000E-02$ MOLES CONVERTED PER PHOTON ABSORBED)
0.001

ENTER MULTIPLICATIVE FACTOR TO ALLOW FOR NATURALLY OCCURRING LIGHT ABSORBERS,
QUENCHERS, AND SENSITIZERS (CURRENT AQS MULTIPLICATIVE FACTOR = 1.000) 1.0

TOTAL PHOTONS ABSORBED (IN PHOTONS / (MOLE * CM^3 * S) FOR EACH COMPARTMENT
ARE

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.1860E+18	0.6220E+17	0.1040E+18	0
ALLEY	0.	0.1040E+18	0.1450E+18	0

DO YOU WISH TO CHANGE ANY ENTRIES? (1) YES (2) NO 2

MULTIPLICATIVE FACTOR FOR HYDROLYSIS DUE TO AIR TEMP. IS OF THE FORM

$$F = E ** (DELHA/1.986) * (T - TO) / (T * TO)$$

WHERE E = NATURAL LOG BASE = 2.718

T = AIR TEMPERATURE (DEGREES K)

TO = 296 DEGREES K

DELHA = ACTIVATION ENERGY (CALORIES/MOLE)

ENTER ACTIVATION ENERGY FOR ABOVE EQUATION
(CURRENT ACTIVATION ENERGY = 13500.00 CAL/MOLE) 12500

MULTIPLICATIVE FACTOR FOR HYDROLYSIS DUE TO SOIL TEMP. IS OF THE FORM

$$F = E ** (SDELHA/1.986) * (T - T0) / (T * T0)$$

WHERE E = NATURAL LOG BASE = 2.718
 T = SOIL TEMPERATURE (DEGREES K)
 T0 = 296 DEGREES K
 DELHA = ACTIVATION ENERGY (CALORIES/MOLE)

ENTER ACTIVATION ENERGY FOR ABOVE EQUATION
 (CURRENT ACTIVATION ENERGY = 13500.00 CAL/MOLE) 12500

The user is next asked if he wishes to change coefficients of attenuation equations based on environmental conditions. If he selects this option, he is required to select a specific attenuation process (microbial degradation, photolysis, hydrolysis, volatilization, oxidation). The appropriate equations are displayed one at a time and the user may enter new coefficients if desired.

Example

DO YOU WISH TO CHANGE COEFFICIENTS OF ATTENUATION EQUATIONS DEPENDENT ON ENVIRONMENTAL CONDITIONS

(1) YES (2) NO 1

DO YOU WISH TO CHANGE COEFFICIENTS OF EQUATIONS DEPENDENT ON ENVIRONMENTAL CONDITIONS FOR

(1) MICROBIAL DEGRADATION (2) HYDROLYSIS (3) OXIDATION 1

MULTIPLICATIVE FACTOR FOR MICROBIAL DEGRADATION BASED ON PERCENT ORGANIC MATTER IS OF THE FORM

$$F = (1.0 + E**(A * (PERCENT ORGANIC MATTER - B)))*C$$

WHERE A = 0.079
 B = -1.850
 C = 1.870
 E = NATURAL LOG BASE = 2.718

DO YOU WISH TO CHANGE THESE COEFFICIENTS? (1) YES (2) NO 2

MULTIPLICATIVE FACTOR FOR MICROBIAL DEGRADATION BASED ON SOIL TEMPERATURE IS OF THE FORM

$$F = A + B * SOILTEMP + C * (SOILTEMP**2)$$

FOR 5 (DEG. C) < SOILTEMP < 52 (DEG. C)
 AND F = 0.0 OTHERWISE
 WHERE A = -0.19520
 B = 0.04480
 C = 0.00080

DO YOU WISH TO CHANGE THESE COEFFICIENTS? (1) YES (2) NO 2

DO YOU WISH TO CHANGE OTHER COEFFICIENTS TO ATTENUATION EQUATIONS?

(1) YES (2) NO 1

DO YOU WISH TO CHANGE COEFFICIENTS OF EQUATIONS DEPENDENT ON ENVIRONMENTAL CONDITIONS FOR

(1) MICROBIAL DEGRADATION (2) HYDROLYSIS (3) OXIDATION 2

MULTIPLICATIVE FACTOR FOR HYDROLYSIS BASED ON PH VALUE IS OF THE FORM

$F = 1.0$, IF $PH < C$

$F = A * PH + B$, IF $PH \geq C$

WHERE $A = 10.490$

$B = -76.810$

$C = 7.430$

ANY MORE REPARAMETERIZATION? (1) YES (2) NO 1

DO YOU WISH TO CHANGE (1) PHYSICAL CHARACTERISTICS OF SITE (2) ATTENUATION PARAMETERS (3) PENETRATION PARAMETERS (4) MOVEMENT PARAMETERS

(5) ORGANISM PARAMETERS 3

CURRENT INITIAL PENETRATION PROPORTIONS ARE:

LEAVES	GRASS	LITTER
--------	-------	--------

0.081	0.240	0.255
-------	-------	-------

WOULD YOU LIKE TO CHANGE THE INITIAL PENETRATION PROPERTIES OF A SPRAY

(1) YES (2) NO 2

CURRENT DAILY PENETRATION PROPORTIONS ARE:

LEAVES	GRASS	LITTER
--------	-------	--------

CANOPY	0.000	0.000	0.126
--------	-------	-------	-------

ALLEY	0.000	0.000	0.156
-------	-------	-------	-------

WOULD YOU LIKE TO CHANGE DAILY PENETRATION PROPORTIONS? (1) YES (2) NO 2

CURRENT DAILY PENETRATED RESIDUE ATTENUATION PROPORTIONS ARE:

LEAVES	GRASS	LITTER
--------	-------	--------

CANOPY	0.010	0.010	0.010
--------	-------	-------	-------

ALLEY	0.010	0.010	0.010
-------	-------	-------	-------

WOULD YOU LIKE TO CHANGE DAILY PENETRATION ATTENUATION PROPORTIONS

(1) YES (2) NO

3. Penetration Parameters

There are three basic penetration parameters for each region and layer in a matrix form. They represent: (1) the initial penetration rate for a spray; (2) the daily penetration proportion of dislodgeable residue that becomes penetrated; and (3) the penetrated residue attenuation proportions.

First, the initial (day of spray) penetration matrix is printed. The user may change any of the entries one at a time. When this is completed, the new matrix is printed out. Second, the daily penetration rate matrix is

printed. The user may again change any of the entries one at a time. When completed, the new matrix will be printed. Finally, the penetrated residue attenuation matrix is allowed to be altered in the same manner.

Example

DO YOU WISH TO CHANGE THESE COEFFICIENTS? (1) YES (2) NO 2

DO YOU WISH TO CHANGE OTHER COEFFICIENTS TO ATTENUATION EQUATIONS?
(1) YES (2) NO 1

DO YOU WISH TO CHANGE COEFFICIENTS OF EQUATIONS DEPENDENT ON ENVIRONMENTAL
CONDITIONS FOR
(1) MICROBIAL DEGRADATION (2) HYDROLYSIS (3) OXIDATION 3

MULTIPLICATIVE FACTOR FOR OXIDATION IS OF THE FORM

$$F = A$$

WHERE A = 1.0000

DO YOU WISH TO CHANGE THESE COEFFICIENTS? (1) YES (2) NO 2

DO YOU WISH TO CHANGE OTHER COEFFICIENTS TO ATTENUATION EQUATIONS?
(1) YES (2) NO 2

4. Movement Parameters

A. SPRAY DISTRIBUTION

The first movement parameter the user is allowed to change is the spray distribution. The spray distribution represents the proportion of pesticide reaching the orchard during spraying that goes to each distinct (region and layer) compartment. The current spray distribution vector is displayed. The user may use this or enter a new spray distribution vector. If he enters a new spray distribution vector, he must enter a proportion for each layer and region. The sum of the proportions he enters must be 1.0. If it is not, it is normalized to one. (Note -- drift losses are accounted for elsewhere in the model.) When completed, the new spray distribution vector is printed.

Example

ANY MORE REPARAMETERIZATION? (1) YES (2) NO 1

DO YOU WISH TO CHANGE (1) PHYSICAL CHARACTERISTICS OF SITE (2) ATTENUATION
PARAMETERS (3) PENETRATION PARAMETERS (4) MOVEMENT PARAMETERS
(5) ORGANISM PARAMETERS 4

CURRENT SPRAY DISTRIBUTION IS:

	LEAVES	GRASS	LITTER	SOIL
CANOPY	0.5392	0.1006	0.0387	0.0299
ALLEY	0.0000	0.0942	0.0300	0.1564

DO YOU WANT TO ENTER A NEW SPRAY DISTRIBUTION? (1) YES (2) NO 2

B. NON-RAIN MOVEMENT MATRIX

After the spray distribution matrix is complete, the non-rain movement matrix is printed. The non-rain movement matrix represents the daily proportions of pesticides that move from one compartment to another (see Subroutine Non-Rain description for more details about how the matrix is applied).

The user has the option to: (1) re-enter any single column of the matrix; (2) display the matrix after changes have been made; (3) increase or decrease the daily proportion of movement of the entire matrix by any multiplicative factor; (4) increase or decrease the daily proportion of a single column by any multiplicative factor; or (5) exit the non-rain movement matrix change mode. He may make any number of changes (1) through (4) until he exits the change mode. Note -- options (3) and (4) do not act directly on the matrix entries. They cause the factor entered to be multiplied by the appropriate instantaneous rates calculated from the off-diagonal elements. The (multiplied) rates are then reconverted to 1-day loss proportions, and the diagonal elements recomputed by subtraction. Thus, a factor of 2 has the effect of making the pesticide "half as sticky," while 0.5 makes it "twice as sticky."

Example

CURRENT NON-RAIN MOVEMENT MATRIX

					FROM			
					C 1	C 2	C 3	C 4
					A 1	A 2	A 3	A 4
C 1	0.9804							
C 2	0.0003	0.9347						
C 3	0.0088	0.0654	0.9073					
C 4	0.0000	0.0000	0.0927	1.0000				
TO A 1								
A 2	0.0001					0.9732		
A 3	0.0094					0.0265	0.9962	
A 4	0.0005					0.0003	0.0038	1.0000

WHERE C=CANOPY REGION, A=ALLEY REGION
1=LEAVES, 2=GRASS, 3=LITTER-MOSS, 4=SOIL
AND COLUMNS MUST SUM TO 1.0

DO YOU WISH (1) TO RE-ENTER A SINGLE COLUMN (2) LOOK AT THE CURRENT NON-RAIN MOVEMENT MATRIX (3) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE MOVEMENT MATRIX BY A MULTIPLICATIVE FACTOR (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (5) EXIT NON-RAIN MATRIX CHANGE MODE 4

ENTER REGION (1) CANOPY (2) ALLEY
LAYER (1) LEAVES (2) GRASS (3) LITTER-MOSS (4) SOIL
OF THE COLUMN VECTOR YOU WISH TO CHANGE 1 1

ENTER FACTOR YOU WISH TO INCREASE OR DECREASE THE RATE OF MOVEMENT BY
(FACTOR MUST BE GREATER THAN ZERO) 2.0

DO YOU WISH (1) TO RE-ENTER A SINGLE COLUMN (2) LOOK AT THE CURRENT NON-RAIN MOVEMENT MATRIX (3) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE MOVEMENT MATRIX BY A MULTIPLICATIVE FACTOR (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (5) EXIT NON-RAIN MATRIX CHANGE MODE 2

CURRENT NON-RAIN MOVEMENT MATRIX

	C 1	C 2	C 3	C 4	FROM A 1	A 2	A 3	A 4
C 1	0.9611							
C 2	0.0006	0.9347						
C 3	0.0175	0.0654	0.9073					
C 4	0.0000	0.0000	0.0927	1.0000				
TO A 1								
A 2	0.0002					0.9732		
A 3	0.0186					0.0265	0.9962	
A 4	0.0011					0.0003	0.0038	1.0000

WHERE C=CANOPY REGION, A=ALLEY REGION
1=LEAVES, 2=GRASS, 3=LITTER-MOSS, 4=SOIL
AND COLUMNS MUST SUM TO 1.0

DO YOU WISH (1) TO RE-ENTER A SINGLE COLUMN (2) LOOK AT THE CURRENT NON-RAIN MOVEMENT MATRIX (3) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE MOVEMENT MATRIX BY A MULTIPLICATIVE FACTOR (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (5) EXIT NON-RAIN MATRIX CHANGE MODE 5

C. RAINFALL MOVEMENT MATRICES (see SUBROUTINE RAINFALL for description of how matrix is applied)

The user is first asked which matrix to display (light or heavy rainfall). The changes made to a rainfall matrix are always to the last rainfall matrix (light or heavy) that was displayed.

When asked to make changes, the user may always display either the light or heavy rainfall movement matrix.

Other than this, changes in rainfall movement matrices are the exact same options as those to the non-rain movement matrix. In the heavy rainfall matrix example below, the movement rate is first doubled, then cut in half to restore the matrix to its original values.

Example

DO YOU WISH TO (1) LOOK AT LIGHT RAINFALL MOVEMENT MATRIX (2) LOOK AT HEAVY RAINFALL MOVEMENT MATRIX (3) MAKE NO RAINFALL MOVEMENT MATRIX CHANGES 1

CURRENT LIGHT RAINFALL MOVEMENT MATRIX

					FROM			
					A 1	A 2	A 3	A 4
TO	C 1	0.9320						
	C 2	0.0296	0.7468					
	C 3	0.0021	0.0708	1.0000				
	C 4	0.0362	0.1824	0.0000	1.0000			
	A 1							
	A 2	0.0001				0.8687		
	A 3	0.0000				0.0000	1.0000	
	A 4	0.0000				0.1313	0.0000	1.0000

WHERE C=CANOPY REGION, A=ALLEY REGION
 1=LEAVES, 2=GRASS, 3=LITTER-MOSS, 4=SOIL
 AND COLUMNS MUST SUM TO 1.0

DO YOU WISH TO (1) LOOK AT CURRENT LIGHT RAINFALL MATRIX (2) LOOK AT CURRENT HEAVY RAINFALL MATRIX (3) RE-ENTER A SINGLE COLUMN OF THE RAINFALL MATRIX YOU ARE WORKING ON (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE CURRENT MOVEMENT MATRIX BY ANY MULTIPLICATIVE FACTOR (5) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (6) EXIT RAINFALL MATRIX CHANGE MODE 4

ENTER FACTOR YOU WISH TO INCREASE OR DECREASE THE RATE OF MOVEMENT BY (FACTOR MUST BE GREATER THAN ZERO) 2.

DO YOU WISH TO (1) LOOK AT CURRENT LIGHT RAINFALL MATRIX (2) LOOK AT CURRENT HEAVY RAINFALL MATRIX (3) RE-ENTER A SINGLE COLUMN OF THE RAINFALL MATRIX YOU ARE WORKING ON (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE CURRENT MOVEMENT MATRIX BY ANY MULTIPLICATIVE FACTOR (5) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (6) EXIT RAINFALL MATRIX CHANGE MODE 1

CURRENT LIGHT RAINFALL MOVEMENT MATRIX

					FROM			
					A 1	A 2	A 3	A 4
TO	C 1	0.8686						
	C 2	0.0572	0.5577					
	C 3	0.0041	0.1237	1.0000				
	C 4	0.0699	0.3186	0.0000	1.0000			
	A 1							
	A 2	0.0002				0.7546		
	A 3	0.0000				0.0000	1.0000	
	A 4	0.0000				0.2454	0.0000	1.0000

WHERE C=CANOPY REGION, A=ALLEY REGION
 1=LEAVES, 2=GRASS, 3=LITTER-MOSS, 4=SOIL
 AND COLUMNS MUST SUM TO 1.0

DO YOU WISH TO (1) LOOK AT CURRENT LIGHT RAINFALL MATRIX (2) LOOK AT CURRENT HEAVY RAINFALL MATRIX (3) RE-ENTER A SINGLE COLUMN OF THE RAINFALL MATRIX YOU ARE WORKING ON (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE CURRENT MOVEMENT MATRIX BY ANY MULTIPLICATIVE FACTOR (5) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (6) EXIT RAINFALL MATRIX CHANGE MODE 4

ENTER FACTOR YOU WISH TO INCREASE OR DECREASE THE RATE OF MOVEMENT BY (FACTOR MUST BE GREATER THAN ZERO) 0.5

DO YOU WISH TO (1) LOOK AT CURRENT LIGHT RAINFALL MATRIX (2) LOOK AT CURRENT HEAVY RAINFALL MATRIX (3) RE-ENTER A SINGLE COLUMN OF THE RAINFALL MATRIX YOU ARE WORKING ON (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE CURRENT MOVEMENT MATRIX BY ANY MULTIPLICATIVE FACTOR (5) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (6) EXIT RAINFALL MATRIX CHANGE MODE 1

CURRENT HEAVY RAINFALL MOVEMENT MATRIX

	C 1	C 2	C 3	C 4	FROM A 1	A 2	A 3	A 4
C 1	0.8209							
C 2	0.0202	0.6126						
C 3	0.0957	0.0000	1.0000					
C 4	0.0082	0.3784	0.0000	1.0000				
TO A 1								
A 2	0.0270					0.2798		
A 3	0.0008					0.4465	1.0000	
A 4	0.0272					0.2737	0.0000	1.0000

WHERE C=CANOPY REGION, A=ALLEY REGION
1=LEAVES, 2=GRASS, 3=LITTER-MOSS, 4=SOIL
AND COLUMNS MUST SUM TO 1.0

DO YOU WISH TO (1) LOOK AT CURRENT LIGHT RAINFALL MATRIX (2) LOOK AT CURRENT HEAVY RAINFALL MATRIX (3) RE-ENTER A SINGLE COLUMN OF THE RAINFALL MATRIX YOU ARE WORKING ON (4) CHANGE THE DAILY PROPORTION OF MOVEMENT OF THE ENTIRE CURRENT MOVEMENT MATRIX BY ANY MULTIPLICATIVE FACTOR (5) CHANGE THE DAILY PROPORTION OF MOVEMENT OF A SINGLE COLUMN BY A MULTIPLICATIVE FACTOR (6) EXIT RAINFALL MATRIX CHANGE MODE 6

D. PROPORTION OF GRASS MOWED

Finally the user is shown the current proportion of grass mowed for a mow date, and asked if he would like to enter a new one. If so, the proportion must be ≥ 0.0 and ≤ 1.0

Example

WOULD YOU LIKE TO CHANGE THE PROPORTION OF GRASS MOWED (CURRENT PROPORTION MOWED = 0.0000) (1) YES (2) NO 1

ENTER PROPORTION OF GRASS MOWED (0.0 to 1.0) 0.40

Example Run of POEM

In the following sample run, the user opted to use weather data supplied on a file, but to enter spray dates manually. The user specified printout of pesticide residues at 5-day intervals, running of only the isopod (Tracheoniscus) model, and other choices as shown. Files for plotting pesticide residues and isopod populations were also created by the run.

Example

EXEC BEGUN.16.18.58

THE FOLLOWING OPTIONS ARE ON BY DEFAULT

ORGANISM SUBMODEL
ATTENUATION SUBMODEL
NON-RAIN MOVEMENT SUBMODEL
PESTICIDE APPLICATION SUBMODEL
RAINFALL MOVEMENT SUBMODEL
PENETRATION SUBMODEL
WRITE FILES FOR PLOTTING PACKAGE
VARIABLE ATTENUATION

OTHER AVAILABLE OPTIONS ARE

MOWER SUBMODEL
WEATHER SIMULATOR
SOIL MOISTURE SIMULATOR
LEAF GROWTH SUBMODEL
MOVEMENT MATRIX DAILY OUTPUT
SOIL TRANSPORTATION SUBMODEL
PESTICIDE PRINTOUT
NON-DEFAULT EVENT DATES -- SPRAYS, MOWS, ETC

DO YOU WISH TO TURN ON OR OFF ANY OPTIONS?

(1) YES (2) NO 1

ENTER A VALUE FOR EACH OPTION

(1) FOR OPTION ON (2) FOR OPTION OFF
OPTION 1 ORGANISM SUBMODEL 1
OPTION 2 MOWER SUBMODEL 2
OPTION 3 ATTENUATION SUBMODEL 1
OPTION 4 WEATHER SIMULATOR 2
OPTION 5 NON-RAIN MOVEMENT SUBMODEL 1
OPTION 6 PESTICIDE APPLICATION SUBMODEL 1
OPTION 7 RAINFALL MOVEMENT SUBMODEL 1
OPTION 8 PENETRATION SUBMODEL 1
OPTION 9 SOIL MOISTURE SIMULATOR 2
OPTION 10 LEAF GROWTH SUBMODEL 2
OPTION 11 MOVEMENT MATRIX DAILY OUTPUT 2
OPTION 12 SOIL TRANSPORTATION SUBMODEL 2
OPTION 13 PESTICIDE PRINTOUT 1

OPTION 14 WRITE FILES FOR PLOTTING PACKAGE 1
 OPTION 15 NON-DEFAULT EVENT DATES -- SPRAYS, MOWS, ETC 1
 OPTION 16 VARIABLE ATTENUATION 1

WHICH ORGANISM SUBMODELS ARE DESIRED (1) YES (2) NO

TRACHEONISCUS? 1
 FOLSOMIA? 2
 SPIDER? 2
 EARTHWORM? 2

HOW MANY YEARS DO YOU WISH TO SIMULATE (ONE TO TEN YEARS) 1

HOW OFTEN (IN DAYS) WOULD YOU LIKE PESTICIDE VALUES PRINTED TO OUTPUT 5

DO YOU WANT TO REPARAMETERIZE THE MODEL (DEFAULT VALUES ARE BASED ON ESTIMATES
 FOR AZINPHOSMETHYL AS GUTHION 50 W.P.)
 (1) YES (2) NO 2

 YEAR 1

ENTER SEASON STARTING DATE 170

ENTER SEASON ENDING DATE 230

HOW MANY SPRAYS DO YOU WISH THIS SEASON (ZERO TO TEN SPRAYS) 2

ENTER DATES CHRONOLOGICALLY

SPRAY DATE 1? 170
 DOSAGE (IN KG./HA.) FOR SPRAY 1? 2.0
 SPRAY DATE 2? 184
 DOSAGE (IN KG./HA.) FOR SPRAY 2? 2.0

SPRAY DATE, DATE 170, SPRAY RATE = 2.00 KG/HA, PERCENT DRIFT OF SPRAY = 50.8

PREDICTED PESTICIDE LEVELS FOR DAY 170

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	6.559	1.012	0.382	0.000	0.578	0.320	0.130	0.396
ALLEY		0.561	0.175	0.000		0.177	0.060	1.226

PREDICTED PESTICIDE LEVELS FOR DAY 170

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	4.697	0.601	0.384	0.000	0.550	0.304	0.372	0.354
ALLEY		0.356	0.175	0.000		0.169	0.196	0.717

PREDICTED PESTICIDE LEVELS FOR DAY 180

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	3.324	0.353	0.279	0.000	0.523	0.289	0.565	0.314
ALLEY		0.221	0.132	0.000		0.160	0.307	0.429

RAIN DATE, HEAVY RAIN DAY 1982

SPRAY DATE, DAY 184, SPRAY RATE = 2.00 KG/HA, PERCENT DRIFT OF SPRAY = 39.0

PREDICTED PESTICIDE LEVELS FOR DAY 184

DISLODGEABLE RESIDUES					PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	10.220	1.445	0.826	0.000	1.219	0.674	0.889	0.912
ALLEY		0.777	0.363	0.000		0.374	1.890	

PREDICTED PESTICIDE LEVELS FOR DAY 185

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	9.563	1.303	0.798	0.000	1.206	0.667	0.983	0.888
ALLEY		0.710	0.353	0.000		0.370	0.518	1.712

PREDICTED PESTICIDE LEVELS FOR DAY 190

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	6.765	0.765	0.582	0.000	0.550	0.634	1.374	0.719
ALLEY		0.441	0.267	0.000		0.352	0.736	0.983

PREDICTED PESTICIDE LEVELS FOR DAY 195

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	4.765	0.449	0.390	0.000	1.091	0.603	1.613	0.541
ALLEY		0.272	0.187	0.000		0.334	0.876	0.547

PREDICTED PESTICIDE LEVELS FOR DAY 200

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	3.369	0.265	0.258	0.000	1.038	0.574	1.738	0.388
ALLEY		0.169	0.130	0.000		0.318	0.956	0.300

RAIN DATE, HEAVY RAIN DAY 203

PREDICTED PESTICIDE LEVELS FOR DAY 205

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	1.938	0.140	0.304	0.000	0.987	0.545	1.844	0.381
ALLEY		0.064	0.115	0.000		0.302	1.010	0.227

RAIN DATE, LIGHT RAIN DAY 208

RAIN DATE, HEAVY RAIN DAY 210

PREDICTED PESTICIDE LEVELS FOR DAY 210

DISLODGEABLE RESIDUES					PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	1.042	0.086	0.259	0.000	0.938	0.519	1.890	0.370
ALLEY		0.030	0.074	0.000		0.288	1.027	0.157

RAIN DATE, LIGHT RAIN DAY 214

PREDICTED PESTICIDE LEVELS FOR DAY 190

DISLODGEABLE RESIDUES					PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	0.694	0.060	0.101	0.000	0.892	0.493	1.907	0.294
ALLEY		0.017	0.036	0.000		0.274	1.018	0.091

RAIN DATE, HEAVY RAIN DAY 218

PREDICTED PESTICIDE LEVELS FOR DAY 220

DISLODGEABLE RESIDUES					PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	0.408	0.031	0.077	0.000	0.849	0.469	1.872	0.220
ALLEY		0.011	0.023	0.000		0.260	0.992	0.065

PREDICTED PESTICIDE LEVELS FOR DAY 225

DISLODGEABLE RESIDUES					PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	0.289	0.019	0.031	0.000	0.807	0.446	1.813	0.142
ALLEY		0.007	0.012	0.000		0.247	0.957	0.038

RAIN DATE, HEAVY RAIN DAY 228

PREDICTED PESTICIDE LEVELS FOR DAY 230

	DISLODGEABLE RESIDUES				PENETRATED RESIDUES			
	LEAVES	GRASS	LITTER-MOSS	SOIL	LEAVES	GRASS	LITTER-MOSS	SOIL
CANOPY	0.170	0.011	0.029	0.000	0.767	0.424	1.744	0.100
ALLEY		0.004	0.009	0.000		0.235	0.918	0.027

END ORCHARD

077000 FINAL EXECUTION FL.

5.068 CP SECONDS EXECUTION TIME.

Producing Graphs

The two plotting programs described below have been written to allow the researchers to conveniently generate Tektronix (CRT) or CALCOMP (pen-and-ink) graphs of pesticide and population levels as generated by POEM. Because they must utilize locally-determined procedures for plotting, they depend on MSU-provided software which is not generally available. Thus, for other sites, more general-purpose plotting packages should be used, working from POEM-generated files as input. These descriptions are provided to illustrate an example working environment in which POEM is conveniently utilized.

Pesticide Graphs

Program ORCHARDCALPLOT allows the user to plot pesticide levels in any region or layer versus time, producing either CALCOMP or TEKTRONIX output. It has available multiple output formats, depending on the user's needs. It can plot the level in a single region based on a single poem run, or can plot one solid and one dashed line, based on two runs, for A, B comparison purposes. It can also display with vertical bars a set of data (usually measured levels, at irregular intervals) for comparison with predicted levels.

The program begins by asking whether TEKTRONIX or CALCOMP plotting is desired. It then presents the user a set of options:

Example

ENTER 1 FOR TEK, 2 FOR CALCOMP...1

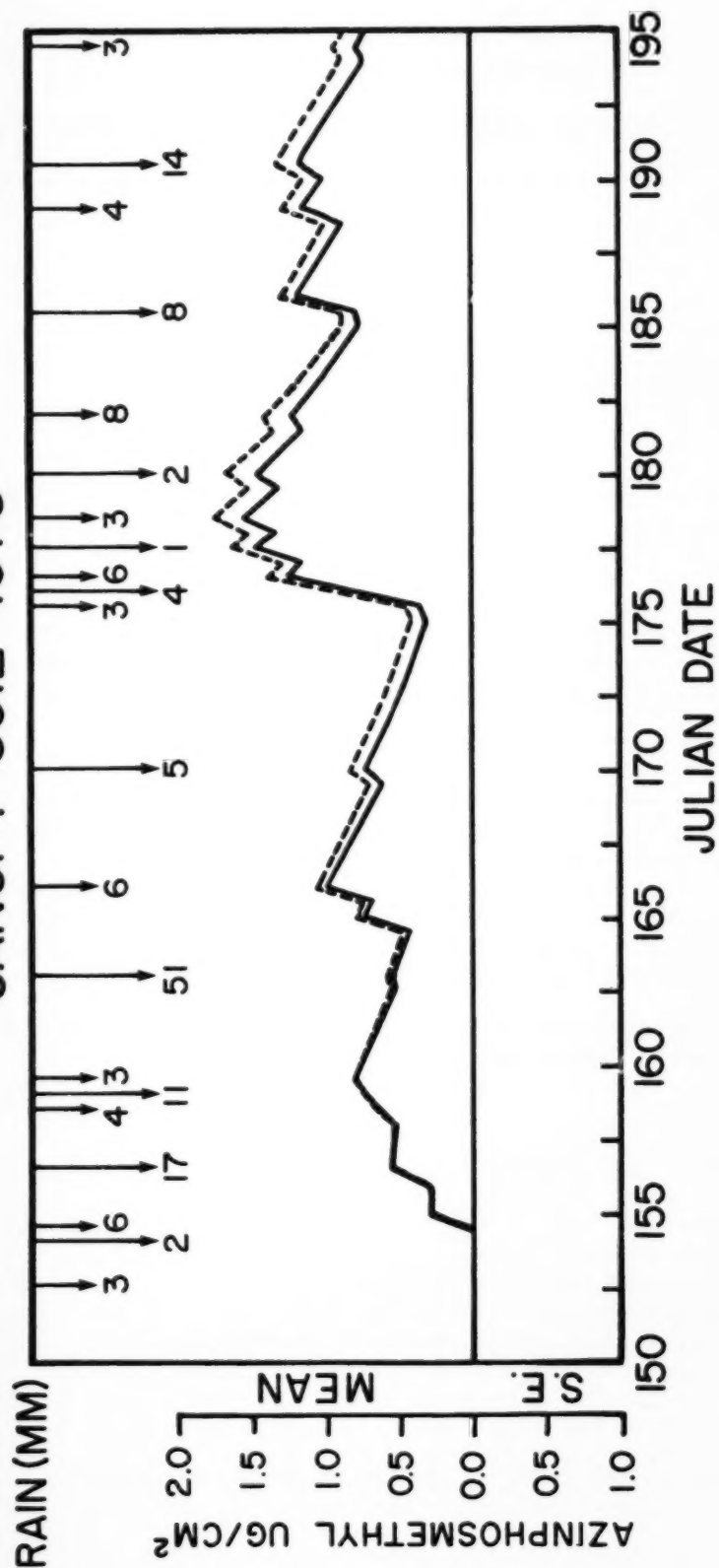
PLOTTING OPTIONS--

- (1) MEASURED AVERAGES ONLY
- (2) MEASURED AVERAGES WITH ONE PREDICTED SET
- (3) MEASURED AVERAGES WITH TWO PREDICTED SETS
- (4) ONE PREDICTED SET ONLY (NO MEASURED AVERAGES)
- (5) TWO PREDICTED SETS WITH NO MEASURED AVERAGES 5

WHAT IS THE BEGINNING YEAR (1 TO 4)?1

WHAT IS THE ENDING YEAR (1 TO 4, AND >= TO BEGINNING YEAR)?1

CANOPY SOIL 1978



The user needs to make sure that appropriate files are available for the option he selects. A single file of predicted residues to be graphed in a solid line must be called TAPE1. An (optional) second file to appear as a dashed line must be called TAPE4. If measured values are to be plotted, they must be called TAPE5. (For plots of outputs of single POEM runs, the correct file is automatically available as TAPE1.) In addition, two files which specify the dates of pesticide spraying and the dates and amounts of rain must be available as TAPE2 and TAPE3, respectively. If a POEM run has just been made, the appropriate TAPE2 and TAPE3 have been created by POEM.

For information on file handling on the MSU Cyber system, see the section on Attaching Tapes.

Organism Graphs

Program ORGPLOT allows the user to plot population levels versus time for single life stages or groups of life stages. It uses the files generated by POEM (called TAPE11, TAPE12, TAPE13, TAPE14, TAPE15). They are created by POEM as follows:

TAPE11 -- non-breeding female ispod populations on each day of the model run, arranged as:

	<u>IN ORGPLOT, LIFE STAGE INDEX</u>
Day number (January 1 year 1 = day 1)	-
Daily egg hatch (not number of eggs present)	1
Size-class 1 (0.5-1.34 mg)	2
Size-class 2 (1.34-5.0 mg)	3
Size-class 3 (5.01-12.0 mg)	4
Size-class 4 (12.01-30.0 mg)	5
Size-class 5 (30.01-50.0 mg)	6
Size-class 6 50.01-80.0 mg)	7
Size-class 7 (>80.0 mg)	8
Total, classes 1-7 (life stage indices 2-8)	9

TAPE12 -- breeding female isopod populations on each day of the model run, arranged as:

Day number	
Blank field (egg hatch stored on TAPE11)	
Size-class 1-3 0.0 (no small breeders)	
Size-class 4 (12.01-30.0 mg)	5
Size-class 5 (30.01-50.0 mg)	6
Size-class 6 50.01-80.0 mg)	7
Size-class 7 (>80.0 mg)	8
Total, classes 4-7 (life stage indices 5-8)	9

(Note that in ORGPLOT, the populations displayed are the sums of breeding and non-breeding populations.)

TAPE13 -- collembola (also called Folsomia in the model, based on data from both Folsomia candida and Folsomia quadrioculata) populations one each day of the model run, arranged as:

Day number	
Egg <u>hatch</u> on current day (<u>not</u> total eggs present)	1
Prejuveniles	2
Juveniles	3
Adults	4
Totals (life stage indices 2-4)	5

TAPE14 -- earthworm populations (see earthworm model for definitions).

TAPE15 -- spider populations on each day of the model run, arranged as:

Day number	
Viable eggs (<u>not</u> hatch)	1
Instar 1	2
:	:
:	:
Instar 8	9
Adults	10
Totals (including eggs)	11

ORGPLOT will expect to find only those files which the user asks to plot (i.e., for isopods -- TAPE11, TAPE12, for collembola -- TAPE13, for earthworms, -- TAPE14, for spiders -- TAPE15). The user is asked for the choice of organisms, a label for the y-axis, and for scale factors for each axis. The x-axis will be scaled at 6 points (with 5 intervals between) and the user may explicitly enter the starting and ending Julian dates (cumulative -- i.e., 370 is day 5 of year 2), or may enter 0,0 to request auto-scaling by the program. A maximum of 1200 days may be displayed. Similarly, the y-(population) axis can be scaled by specifying an upper limit, or the program will auto-scale it if a 0 is entered.

The user is next asked for a size-class range to plot. This is given by specifying the number of the beginning and ending size-classes, in ascending order -- i.e., for size classes 2-4, enter 2,4; to see only size class 3, enter 3,3.

After a graph is generated, the user may shoot a hard copy (TEKTRONIX) before the program contaminates the screen with any further question. When ready to proceed, the user should type a space and return, to produce the next question. He may request another graph, or may quit the program. In CALCOMP mode, the program immediately prompts for further actions, after indicating that the plot file has been submitted for plotting (an off-line procedure).

Example

ENTER 1 FOR TEK, 2 FOR CALCOMP: 1

WHICH ORGANISM DO YOU WISH TO PLOT

- (1) TRACHEONISCUS
- (2) FOLSOMIA
- (3) SPIDER
- (4) EARTHWORM 1

ENTER Y-AXIS LABEL FOR GRAPH SAMPLE ISOPODS

ENTER X LOWER, UPPER LIMITS, OR 0,0 FOR AUTOMATIC: 0,0

ENTER Y UPPER LIMIT, OR 0 FOR AUTOMATIC: 0

ENTER LIFESTAGE RANGE TO PLOT: LOWER,UPPER INDICES: 2,4

Attaching Tapes

Disk files which are to be read or written during the operation of POEM and its associated plotting programs on MSU's CYBER are locally referred to as TAPEs. This naming is to agree with local file names specified in the PROGRAM statement at the beginning of each program. At MSU, there are two types of disk files: local files and permanent files. Permanent files may be read and/or written only by "attaching" them to (temporary) local file names. TAPE1, TAPE2, etc. are examples of such local file names. Thus, if the user wants to plot data from permanent files stored after earlier runs (see below), he must first "attach" the permanent file to local files, as shown below:

ATTACH,TAPE1,PREDICTEDRUN1,PW = _____.

This command makes the permanent file PREDICTEDRUN1 accessible as TAPE1, assuming that the correct password was specified after "PW = ". Similar commands will retrieve stored weather data.

In the simplest types of use, the user need not concern himself with these file issues: POEM automatically attaches the permanent file "WTHRSTATSNEW" if the weather simulator is turned off, and the file "PWSMOIST2" if the soil moisture submodel is turned off. POEM also creates (if plotting option is on) the SPRAYDATES(TAPE2) AND RAINAMOUNTS(TAPE3) files required by DATAPLT to plot the pesticide levels generated by this run (on TAPE1). Thus, the user need not perform explicit ATTACH commands if he is using data just generated by the model.

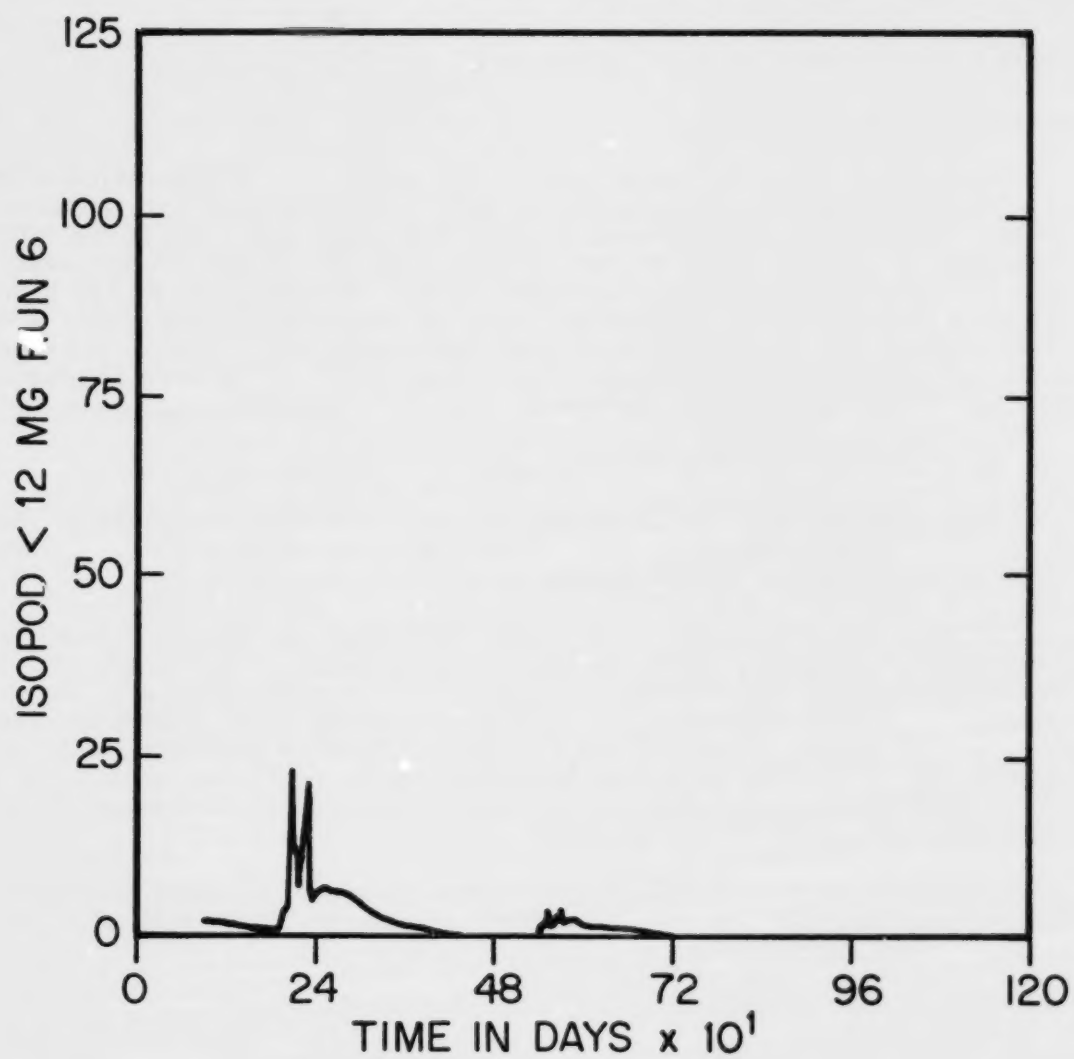
Note -- if POEM is to be run after other programs (or POEM) have been run in the same session, the user must first release the files POEM will try to attach: namely, type:

RETURN, TAPE4, TAPE9.

File Conventions in POEM Programs

POEM may read: TAPE4 -- weather data (which it attaches as WTHRSTATSNEW)

TAPE9 -- soil moisture data (which it attaches as PWSMOIST2)



POEM creates (depending on options selected)

- TAPE1 -- pesticide levels
- TAPE2 -- spray dates
- TAPE3 -- rain amounts
- TAPE11 -- isopod non-breeding populations
- TAPE12 -- isopod breeding populations
- TAPE13 -- collembolan populations
- TAPE14 -- earthworm populations
- TAPE15 -- spider populations

DATAPLT (stored on file ORCHARDCALPLOT6) uses:

- TAPE2 -- spray dates
- TAPE3 -- rain amounts
- (TAPE1 -- predicted pesticide levels, to be plotted as solid line -- optional)
- (TAPE4 -- predicted levels, to be plotted as dashed line -- optional)
- (TAPE5 -- measured pesticide levels, to be plotted as vertical bars -- optional)

ORGPILOT uses:

TAPES11-15 as shown above.

Users wishing to run these programs at other sites should replace the CDC-specific PROGRAM statements, which also control file access, with appropriate file handling statements. In particular, in FORTRAN77, the standard OPEN statements could instead be used.

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Addendum to User's Manual

Notice

Due to lack of funds and consequent lack of computer and manpower resources, some features and options of POEM are untested and/or undebugged. While the bulk of the code required to exercise all of the options described here is written, and all subroutines have run at various times as independent units, the linking of some routines has not been completed. Known problems are listed below:

- (Option 2) Weather simulation -- not operable. Weather information must instead be provided in a file (TAPE4).
- (Option 12) Soil transportation model -- not operable. Pesticide levels in soil cannot be broken down by depth.
- (Option 9) Soil moisture model -- not operable. Soil moisture information must be provided in a file (TAPE9).